Single Munition Variable Velocity Non-Lethal Ballistic System for Fires Near the Muzzle to More Than 100 Meters

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Introduction

- Blunt impact non-lethal weapons are difficult to employ across operationally useful ranges: muzzle to 100 meters.
  - They are only effective over a small interval of distance due to impact velocity and accuracy limitations.
- Multiple weapons and munitions are required.
  - Complicating logistics and training.

There is a need for a single weapon/munition capable of effective non-lethal fires from the muzzle to > 100 meters.
A Single Weapon/Munition Must be Predictable at all Useable Ranges

- Consistent terminal effects ease decision making and use.
  - Impact velocity needs to be constant (± 5 m/sec.) across the entire range of engagement distances
  - Accuracy across the entire range of engagement distances keeps impact to the same region on the bodies of the intended targets.

- Effective integration by the user
  - Ease of use: simple operation
  - Small and lightweight
Risk of Significant Injury (RSI): Metric for Use

- RSI is used by commanders to determine if a non-lethal weapon should or should not be deployed.
- RSI is strongly influenced by impact velocity and location.
- Impact velocity decreases with range.
  - Reduces RSI and effectiveness.
  - Results are less predictable.
- Accuracy degrades with range increasing likelihood of undesirable effects:
  - Increased RSI from impact to the neck face or head.
  - Collateral damage (impact to bystanders).
  - Ineffective fires due to outright misses.
- RSI and effectiveness vary with range to the target.
Pain Compliance Produces RSI

Balancing Effective Impact Velocity and RSI

- For each projectile there is a **minimum impact velocity** needed to achieve the desired level of pain compliance, varies across the body.
- For each impact location there is a **maximum impact velocity** that should not be exceeded (or there is a high probability of severe injury).
- In general the least vulnerable parts of the body are the heavy muscle groups of the legs and buttock.
- For consistency in training the aim point is center of mass.
  - the torso the primary impact location.
- “Safe” and effective impacts to the torso are also good against the extremities, but impacts to face, neck, head, and groin likely produce severe injury.
- Effective range of a weapon/munition is where:
  - Impact velocity produce pain compliance with low risk of torso injury.
  - Accuracy is sufficient that aimed fire only impacts the torso and extremities >90% of the time.
  - Usually small 10 to 20 meters in length and **limited by accuracy decay**
Requirements for Single Weapon/Munition: Muzzle to 100 M

- Impact effects must be nearly constant (bracketed)
  - Simplifies and speeds decision process

- Impact location in torso and extremities on the intended target.
  - Proper zero of the weapon
  - Accurate ranging
  - Articulation of weapon or site for correct zero at each range

- Easy to use, fast to deploy.
  - Modular accessory for M4 with regulation of lethal and NL site
  - Fire control for all complex actions:
    - Accurate ranging (to <5m accuracy)
      - Automated control of all range related weapon settings
      - Articulation of NL weapon to compensate for range and maintain regulation with lethal site
Battelle Variable Velocity Prototype
Battelle Variable Velocity Prototype
Accurate Fires

- **The Weapon**
  - Mechanically repeatable platform
  - Precision barrel

- **The sites**
  - Precise
  - Repeatable
  - Adjustable for all shooting ranges

- **The Munition**
  - Consistent muzzle velocity shot-to-shot
  - Aerodynamic stability over the entire trajectory

- **The Shooter Skill**
  - Five fundamentals of marksmanship
# Doppler Radar Results

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Keeping Impact Velocity Bracketed, Ideal Behavior
Vertical Dispersion at 100 meters

Low Yaw and High Yaw Rounds

- Extreme Spread approximately 6 m/sec.
  - Approximately ± 20 cm vertical dispersion
- Difference in average impact velocity approximately 15.5 m/sec
  - High yaw approximately 95 cm below low yaw
Dealing with Large Vertical Dispersion: Zeroing at Each Range

- Classic small arms zero: the geometric center of the group.
  - Works well when the group size is small.

- For large vertical dispersion placing the zero at the geometric center puts 50% of shots high.
  - Large risk of an impact to the neck, face, and head.

- For large vertical dispersion Weapon should be zeroed to the highest impact points of the group.
27 M zero to the average round
Zero at 100 M to the Most Aerodynamic Rounds
Arched Trajectory and Multiple MV

At long range each elevation setting may cover <5m on the ground.

At ranges <30 m single velocity and single site setting.

50 meter range

25 meter range

AIV “window on the ground”

100 meter range

point blank range decreases rapidly

collateral damage range

Each velocity setting may cover 20-25 meters, but at long range 2 to 4 elevation settings may be required for each velocity setting.
Multi-Muzzle Velocity Weapons Too Complex for Manual Control

Accurate ranging, muzzle velocity selection, elevation adjustment: Too complex to do well under field conditions

- 4 to 5 muzzle velocities
- 9 to 10 elevation settings
- Ranging resolution < 5 meters
- Environmental considerations
  - Wind
  - Temperature
  - Light

Fire Control
Fire Controls are not Cheap

Non-Lethal Fires are a Small Subset of Small Arms Fires
Integrating Non-Lethal and Lethal Fires in One Control
Distributes Cost Over Multiple Missions

Range target, electromechanically select muzzle velocity,
electromechanically adjust NL weapon elevation regulating NL Point of Aim
co-incident with Lethal Point of Impact
Single Site Setting for Lethal and Non-Lethal Fires.
Next Steps

- Improve aerodynamic stability preventing bi-modal terminal velocity and very large vertical stringing
- Develop a reliable auto-loading multi-shot
- Integration of commercial fire control
  - Articulation of non-lethal weapon (maintain NL impact coincident with parent weapon sight)
  - Automatic selection of muzzle velocity based on user input of desired effect, environmental conditions and measured range to target
- Improved manufacturability of munition
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